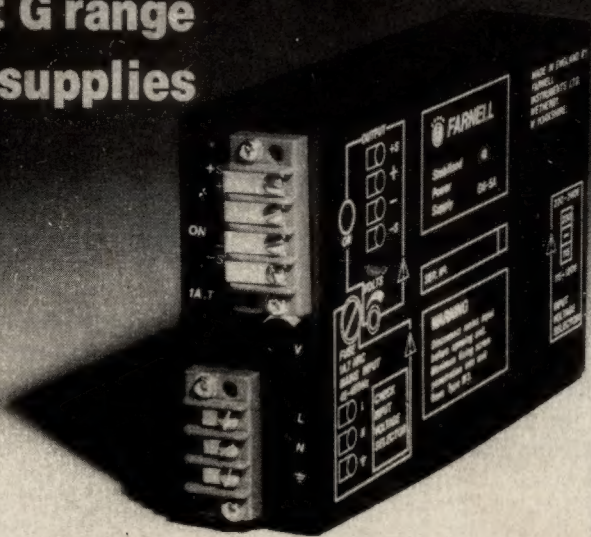


# Instruction book for 30 Watt G range power supplies



# Farnell

## SCHEDULE OF EQUIPMENT

The unit has been carefully packed to prevent damage in transit. When removing the unit from the box ensure that all parts and accessories are removed from the packing material.

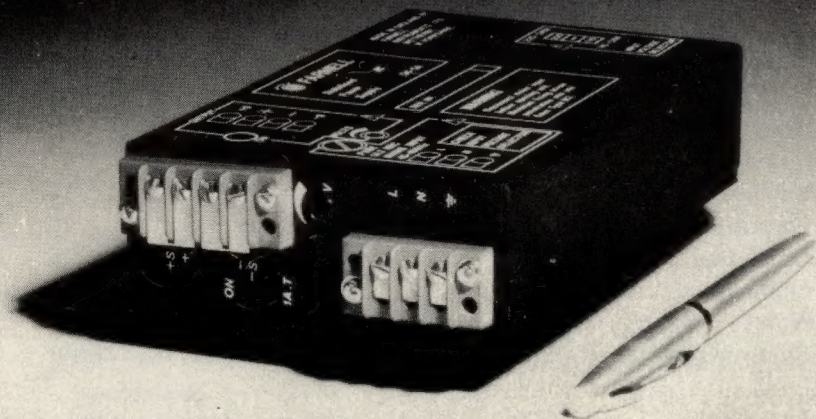
The complete equipment comprises:-

- a) 1 off G range power supply of the type specified on order.
- b) 1 off instruction book.
- c) 1 off packet of accessories comprising:-
  - 1 off spare fuse.
  - 2 off flat washers.
  - 2 off spring washers.
  - 7 off terminal tags.
  - 2 off fixing screws 8mm long (see note in paragraph 'Mounting and ventilation' on page 8).
  - 1 off optional fixing bracket.

## CONTENTS

Introduction .....	1
Specification .....	2
Operating instructions .....	6
Hold-up time graphs.....	9
Circuit description .....	11
Schematic diagram .....	14
Mechanical details .....	15
Guarantee .....	16
Maintenance .....	17
Notes .....	18
Circuit diagram .....	rear cover

# The G6-5M power supply



## INTRODUCTION

The Farnell 30 watt G range power supplies use a switching technique to provide stabilised d.c. from a.c. inputs. Use of these techniques has permitted the production of very compact lightweight, high efficiency power supplies which will work from a wide range of mains input voltages.

Four different units are available in the same mechanical package. These are based on combinations of output voltage and current which give a maximum output power of approximately 30 watts.

Each unit will operate from a nominal mains input voltage of either 220 to 240V or 115 to 120V, the range being set by a voltage selector switch on the rear panel.

The output voltage setting may be varied by screwdriver adjustment of the front panel potentiometer and the presence of output voltage is indicated by a front panel L.E.D.

Output current limiting and overvoltage protection are provided. The output voltage may be remotely sensed at the load to correct for voltage drop in the load connecting leads.

The units meet international specifications for conducted radio frequency interference and input to output isolation.



## SPECIFICATION

### MAINS INPUT

220 to 240V or 115 to 120V set by voltage selector switch 45 to 440Hz.

### MAINS VARIATION TOLERATED

220V -20% to 240V + 10%.  
115V -20% to 120V + 10%.

### OUTPUTS

Unit	Nominal output voltage	Max. output current	Voltage adjust. range
G6-5M	6V	5A	4 to 6V
G12-2.5M	12V	2.5A	8 to 13.2V
G15-2M	15V	2A	10 to 16.5V
G24-1.4M	24V	1.4A	16 to 26.4V

### OUTPUT VOLTAGE REGULATION

0.1% maximum variation for a worst case combination of 0 to 100% load change and 220V -10% to 240V + 10% or 115V -10% to 120V + 10% line change.

### RIPPLE AND NOISE

at full load (30MHz bandwidth)

Less than 10mV r.m.s.; 50mV pk to pk.

TEMPERATURE COEFFICIENT  $\pm 0.01\%$  per  $^{\circ}\text{C}$  typical.

### TRANSIENT RECOVERY TIME

Typically 1mS for output to recover within 50mV following a 10% to 100% or 100% to 10% load change of 5 $\mu$ S risetime. Typical instantaneous output deviation 400mV.

### OPERATING AMBIENT TEMPERATURE RANGE

-10  $^{\circ}\text{C}$  to +55  $^{\circ}\text{C}$  for full load output current. Convection cooled free air rating

### MAXIMUM OPERATING AMBIENT TEMPERATURE

70  $^{\circ}\text{C}$  max. Output current should be derated linearly from full load at 55  $^{\circ}\text{C}$  to half load at 70  $^{\circ}\text{C}$ .

### STORAGE TEMP. RANGE

-40  $^{\circ}\text{C}$  to +85  $^{\circ}\text{C}$

### HOLD-UP TIME

Output will be maintained for the duration of a missing mains cycle (28mS) at maximum output current and 220V -10% or 115V -10% mains input, when the output is at 6V for 6V nominal units or nominal +5% for other units. See graphs on page 9 and 10

**SWITCH ON SURGE**

Less than 80A

**SWITCH ON TIME**

Output established within 30mS

**INSULATION**

Tested at 2.1kV peak for 1 minute between a.c. input and d.c. output, with output terminals and earth connected together.  $\pm 250\text{V}$  d.c. continuous rating between output and earth. Tested to 500V d.c. for 1 minute.

**REMOTE SENSING**

Up to 5V max. drop in each output lead permitted. However unit output terminal voltage must not exceed 6V for nominal 6V units, or nominal  $+5\%$  for other units.

**EFFICIENCY**

Better than 70% at full load

**PROTECTION***Overload*

Current limiting set at  $110\% \pm 5\%$  of full load current with the short circuit current  $100\% - 130\%$  of full load current.

**SERIES AND PARALLEL OPERATION***Overvoltage*

Set at nominal output voltage  $+20\%$ . Disables control circuit and output falls to zero. Reset by interrupting the mains input supply.

*Fuse*

The a.c. input is fused (fuse type 1A.T.)

**RADIO FREQUENCY INTERFERENCE**

Any number of units with the same output voltage may be connected in parallel. Outputs of similar current rating may be connected in series up to a maximum total output voltage of 250V

Units will comply with the conducted interference requirements of VDE0875 curve N, CISPR (publication 2) curve N and BS800

**DIMENSIONS  
(excluding terminals)**

145 x 88 x 33mm

**WEIGHT**

750g




## OPERATING INSTRUCTIONS

### WARNING!

Hazardous voltages exist at many points within the unit. **DISCONNECT THE MAINS INPUT SUPPLY BEFORE OPENING THE UNIT.** If the unit requires servicing it is recommended that it be returned to the manufacturer.

### MAINS INPUT

The mains input terminals are on the 3 way front panel terminal block and are marked L (live), N (neutral) and  (earth). The unit will operate from either a 115 to 120V supply or a 220 to 240V supply and this should be set by the voltage selector switch on the rear panel of the unit before connecting the mains input supply. For 115 to 120V operation set the voltage selector to 115V. For 220 to 240V operation set the voltage selector to 230V.

**WARNING: INCORRECT SETTING OF THE INPUT VOLTAGE SELECTOR SWITCH MAY RESULT IN DAMAGE TO THE UNIT.**

### OUTPUT CONNECTIONS

The output connections are taken from the terminals marked '+' and '-' on the 4 way front panel terminal block. Ensure that the '+' terminal is linked to the '+' terminal and the '-' terminal linked to the '-' terminal unless remote sensing is being used. The presence of output voltage is indicated by the front panel L.E.D. adjacent to the terminal block.

### REMOTE SENSING

In order to correct for voltage drop in the load connecting leads, the voltage at the load may be remotely sensed. To do this remove the metal links supplied from the '+ s', '+', '-', and '-s' terminals, connect the load leads to the '+' and '-' terminals in the normal way and connect the '+ s' and '-s' terminals to the point at which regulated voltage is required, observing polarity.

When using remote sensing the unit terminal voltage (i.e. load voltage + total lead drop) should not exceed 6V for 6V nominal units and nominal output voltage + 5% for other units in order that full output specification be maintained. Additionally there is a limitation of 5V maximum drop in each output lead.

### OUTPUT VOLTAGE ADJUSTMENT

The output voltage may be set (without derating max. output current) anywhere within the range shown in the unit specification, by screwdriver adjustment of the front panel 'VOLTS' potentiometer.

### SERIES AND PARALLEL OPERATION

Any number of units with the same nominal output voltage may be connected directly in parallel.

Units with the same output current rating may be connected directly in series up to a maximum total output voltage of 250V.

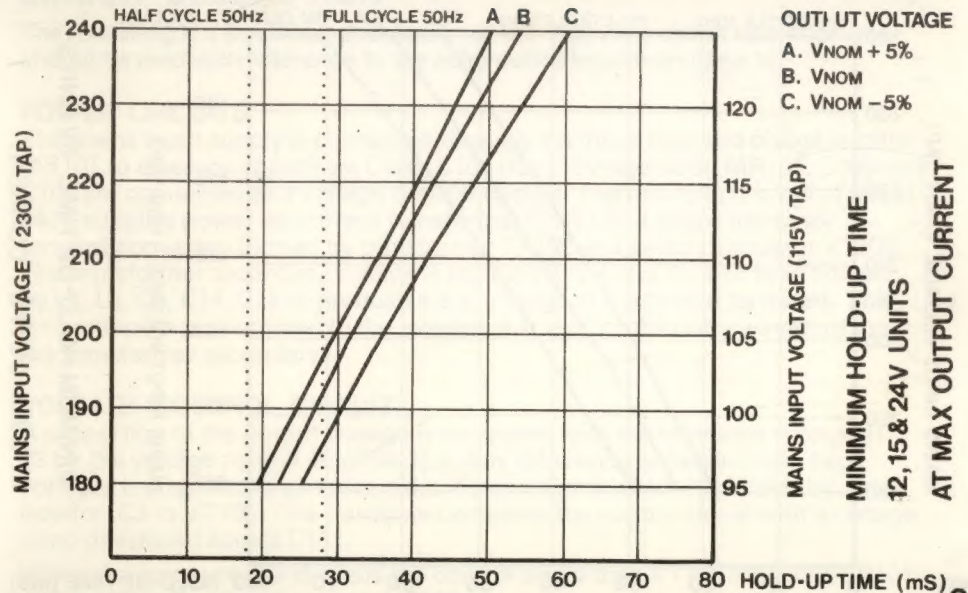
## MOUNTING AND VENTILATION

The unit may be operated in any position but provision should be made to allow free air circulation around the unit, since cooling is by natural convection. The unit is provided with M3 threaded fixing holes in the base and left-hand side. NOTE: fixing screws must not penetrate the unit by more than 6mm (8mm long fixing screws are supplied).

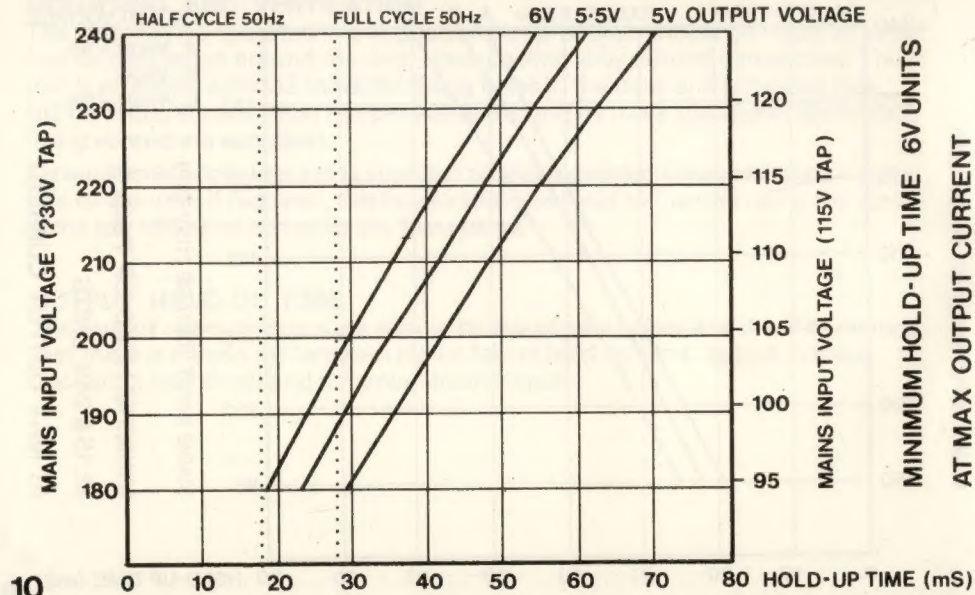
An additional angle bracket is supplied to give extended fixing centres on the side of the unit. If required, this bracket may be fixed to the unit using the screw in the top left-hand corner of the front panel.

## OUTPUT HOLD-UP TIME

The output characteristics are shown by the graphs below and it will be seen that there is a trade off between mains failure hold-up time, output voltage (including lead drop) and minimum mains input.







## CIRCUIT DESCRIPTION

The following is a simplified description of the G'30 watt circuit operation and should be read with reference to the schematic diagram on page 14.

### POWER CIRCUITS

The mains input supply is connected through the input filter and bridge rectifier MR101 to reservoir capacitors C105, C106 (for 115V operation MR101, C105 and C106 are connected as a voltage doubler circuit). The resulting d.c. rail of about 340V supplies power via current transformer TX101 to a single transistor forward converter, formed by transformer TX102 and switch transistor VT106. The transformer secondary voltage is rectified by D4 and D5 and then filtered by L1, L2, C9, C14, C15 to produce a d.c. voltage at the output terminals. This d.c. voltage is proportional to the average d.c. level of the pulse waveform on the transformer secondary.

### VOLTAGE CONTROL CIRCUIT

A proportion of the output voltage is compared with the reference voltage at Z3 by the voltage control amplifier IC4. Any difference between these two voltages is amplified to produce a d.c. control signal which is coupled by opto isolator IC3 to VT105. This transistor compares the control signal with a voltage ramp developed across C111.

When the ramp voltage exceeds the control signal then VT105 triggers SCR101 which pulls off switch transistor VT106.



Conduction of VT106 is initiated by clock pulses generated at a frequency of 30kHz by PUT101 and VT102. VT106 is maintained in conduction by regenerative feedback from current transformer TX101, until SCR101 conducts. At this point VT106 ceases to conduct until driven by the next clock pulse.

In this way, the conduction time of VT106, and hence the average secondary voltage from transformer TX102, can be varied by the d.c. control signal to stabilise the power supply output voltage.

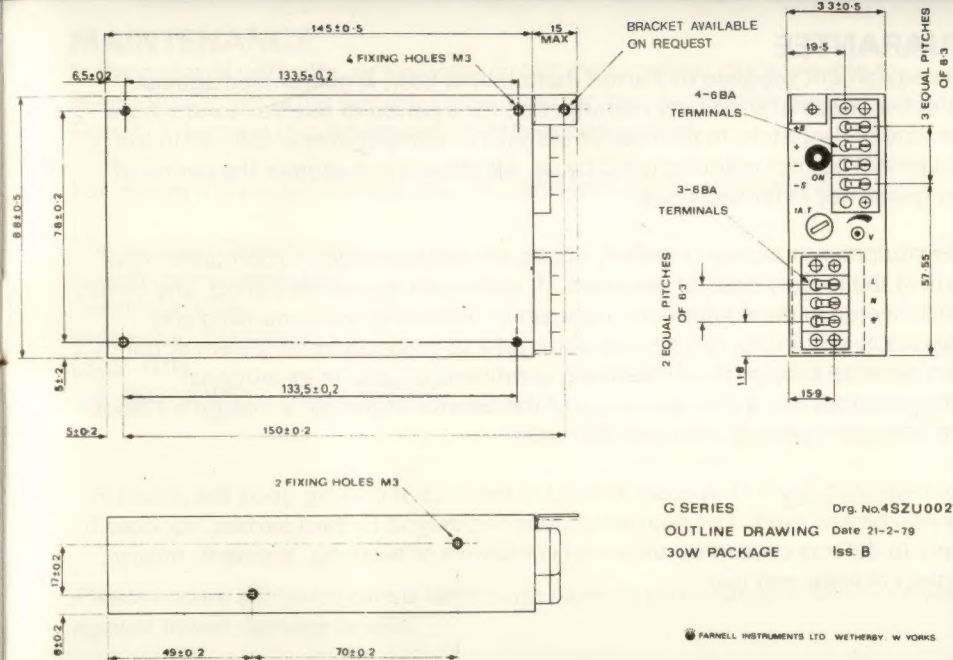
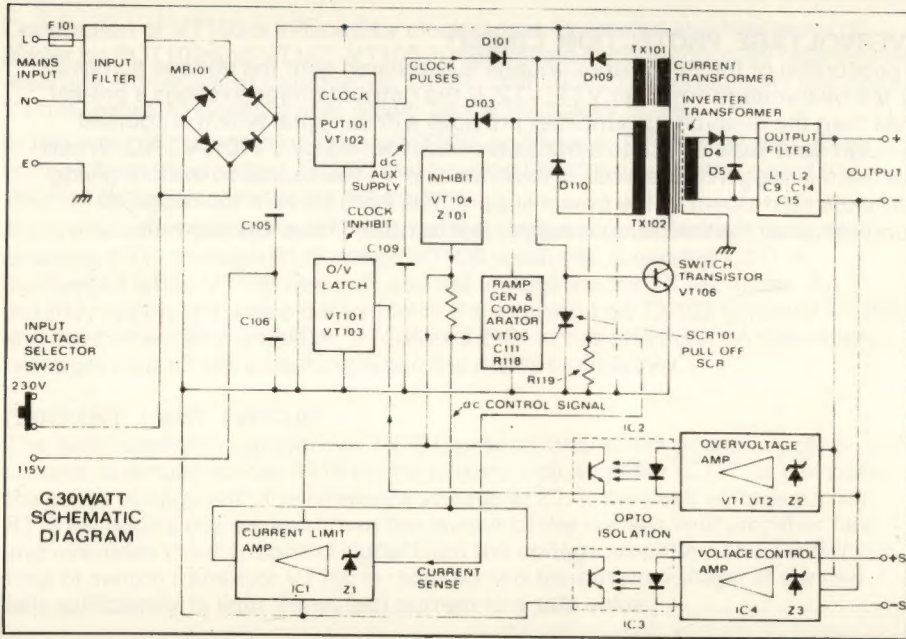
An overwind on transformer TX102 is used to generate the voltage ramp by charging C111 through R118, when VT106 conducts. Capacitor C111 is discharged when VT106 turns off and the voltage across TX102 drops. An auxiliary supply rail is also derived from the overwind on TX102 to power VT105 and the current limit amplifier. VT104 and Z101 act as an inhibit on this supply rail to prevent VT106 switching when the mains input is low.

### **CURRENT LIMIT CIRCUIT**

The peak current in transformer TX101, proportional to the power supply output current, is sensed across R119 by the current limit amplifier IC1. This compares the sense voltage with the reference voltage at Z1. If the peak voltage across R119 exceeds a pre-set level then the output of the current limit amplifier falls and overrides the d.c. control signal from the voltage amplifier. The conduction time of switch transistor VT106 is reduced and the output voltage of the unit falls sufficiently to limit the output current to a safe value.

### **OVERVOLTAGE PROTECTION CIRCUIT**

A proportion of the unit output voltage is compared with the voltage across Z2 by the overvoltage amplifier VT1, VT2. If the output voltage exceeds a pre-set level then the overvoltage amplifier provides a drive signal which is coupled through opto-isolator IC2 to a transistor latch formed by VT101, VT103. When this latch is triggered the clock is inhibited and VT106 ceases to switch, giving complete shut-down of the power supply. The latch stays in the triggered condition until the mains input supply is interrupted for a few seconds.





## **GUARANTEE**

The equipment supplied by Farnell Instruments Ltd., is guaranteed against defective material and faulty manufacture for a period of twelve months from the date of despatch. In the case of material or components employed in the equipment but not manufactured by us, we allow the customer the period of any guarantee extended to us.

The equipment has been carefully inspected and submitted to comprehensive tests at the factory prior to despatch. If, within the guarantee period, any defect is discovered in the equipment in respect of material or workmanship and reasonably within our control, we undertake to make good the defect at our own expense subject to our standard conditions of sale. In exceptional circumstances and at the discretion of the Service Manager, a charge for labour and carriage costs incurred may be made.

Our responsibility is in all cases limited to the cost of making good the defect in the equipment itself. The guarantee does not extend to third parties, nor does it apply to defects caused by abnormal conditions of working, accident, misuse, neglect or wear and tear.

## **MAINTENANCE**

In the event of difficulty, or apparent circuit malfunction, it is advisable to telephone (or telex) the Service Department or your local Sales Engineer or Agent (if overseas) for advice before attempting repairs.

For repairs it is recommended that the complete unit be returned to:-

The Service Department,  
Farnell Instruments Ltd.,  
Sandbeck Way,  
Wetherby, Yorkshire.  
LS22 4DH.  
Tel. 0937 61961. Telex 557294.

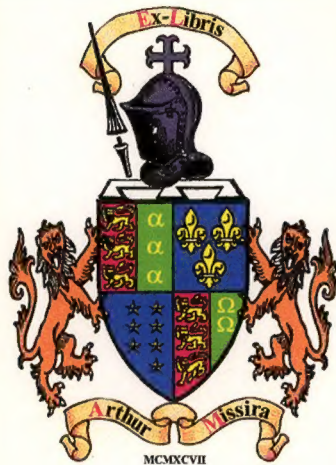
Please ensure adequate care is taken with packing and arrange insurance cover against transit damage or loss.

## NOTES

**Note:-** In the event of damage in transit or shortage in delivery, separate notices in writing should be given to both the carriers and Farnell Instruments Ltd., within three days of receipt of goods, followed by a complete claim within five days. All goods which are the subject of any claim for damage in transit or shortage in delivery should be preserved intact as delivered, for a period of seven days after making the claim, pending inspection or instructions from Farnell Instruments Ltd., or an agent of this Company.



R	123	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519	1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567	1568	1569	1570	1571
---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------







**Farnell**

FARNELL INSTRUMENTS LIMITED  
SANDBECK WAY · WETHERBY  
WEST YORKSHIRE LS22 4DH · TEL. 0937 61961  
TELEX 557294

REGIONAL OFFICE (SOUTH)  
TEL. 05827 69071  
TELEX 826307